Sustainable agriculture: Guaranteeing yield while reducing greenhouse gases

January 24 2020

Mario Corrochano-Monsalve. Credit: UPV/EHU

The NUMAPS group of the UPV/EHU has analyzed the benefits of adding nitrification inhibitors to ammonium-based fertilizers. The study was conducted on a wheat crop and compared a conventional tillage management system with one involving minimum tillage. To do this,

parameters such as grain yield and quality, efficiency in nitrogen use and greenhouse gas emissions, among other things, were measured.

Crop growth is limited by the nitrogen availability in the soil, one of the primary elements of plants, the deficiency of which leads to a fall in agricultural yield. So nitrogen needs to be added to the soil in the form of nitrogen fertilizers. Yet this applied nitrogen may not be efficiently used by the crop. This fact not only leads to significant economic losses for the farming sector, it causes environmental problems, such as water eutrophication due to nitrate leaching, ammonia volatilization, and production of nitrogen oxide (nitric oxide and nitrous oxide) produced by the microorganisms in the soil. The emission of nitrous oxide (N_2O) is hugely significant, as it is a greenhouse gas with a global warming potential 265 times higher than that of CO_2.

In order to mitigate these nitrogen losses in agriculture, "agronomic research has to focus on optimizing the use of nitrogen fertilizers by developing better farming practices that will not only help to prevent leaching and gaseous losses, but also to obtain maximum crop yield and quality," says Ph.D. student Mario Corrochano-Monsalve, one of the researchers in the NUMAPS (NUtrition MAnagement in Plant and Soil) group of the UPV/EHU.

In this respect, the researchers have conducted a study focusing on the use of nitrification inhibitors. Inhibitors of this type slow down the activity of certain bacteria that inhabit agricultural soils and which use the ammoniacal nitrogen provided by the fertilizers for their own growth, thus competing with the plant crop for it. "The use of inhibitors enables the plant to have more time to absorb nitrogen from the soil and assimilate it in the form of amino acids and proteins, thus reducing its loss in the form of nitrates or nitrogen gases," explained the researcher.

Toward efficient agriculture

The group conducted a field experiment "to see the effect of using an ammoniacal fertilizer combined with a type of nitrification inhibitor (3,4-dimethylpyrazole-succinic acid DMPSA) on two crop management systems: conventional tillage (deep furrows with moldboard) and minimum tillage (minimum plowing, the seeds being sown in small holes)," according to Corrochano-Monsalve.

The plots were exhaustively monitored. Corrochano-Monsalve says, "On each plot, we measured the wheat yield, its quality as bread flour, the evolution in soil nitrogen content and greenhouse gas emissions (GHG) (CO_2, N_2O and CH_4) of the cultivated soil; the genetic indicators of the variation of bacteria populations in the soil responsible for nitrogen oxidation/reduction and therefore its emission as GHG were also analyzed."

The main conclusion of the study is that "the use of the nitrification inhibitor in combination with minimum tillage improved crop efficiency, and reduced the GHG emission without affecting yield," explains Corrochano-Monsalve. "The most novel aspect of the work is the confirmation that the use of nitrification inhibitors on crops with a minimum tillage system encourages the growth of certain bacteria populations that reduce the N_2O to molecular nitrogen (N_2), the most abundant form and which does not react with the nitrogen in the atmosphere. That way, the loss of nitrogen in the form of gas would be harmless."

In humid Mediterranean climate conditions, like that of Álava, where the study was conducted, "in many phases of the crop cycle, we find high levels of soil humidity that may increase nitrogen losses through leaching. Yet the high degree of humidity also generates a highly anaerobic environment that encourages the reduction of N oxides to N_2," he says. "The use of nitrification inhibitors can be expected to enable a smaller amount of fertilizer to be applied, which, besides a reducing the

environmental impact, would lead to economic savings for farmers.

"Agriculture, just like many other sectors, has to be more and more efficient. It is about achieving sustainable agriculture that combines food security (food for everyone) with the minimum environmental impact," he concludes. Until now, general recommendations have been made for each geographical area (amount of fertilizer, chemical formulation, when and how to apply it, type of plant protection products, etc.). However, the ideal thing, and which is a growing trend, is to customize the recommendations much more. In other words, even each plot within a single geographical area has its unique features, and the ideal thing would be before the start of a growing season for each plot to be analyzed beforehand to determine exactly what its needs are and thus prevent the wasting of resources."

More information: Mario Corrochano-Monsalve et al. Relationship between tillage management and DMPSA nitrification inhibitor efficiency, *Science of The Total Environment* (2019). DOI: 10.1016/j.scitotenv.2019.134748

Provided by University of the Basque Country